Form and Slab Insulation

Photo by courtesy of Wood Conversion Company

ALTHOUGH BY NO MEANS a new development, the insulation of fresh concrete as a means of protecting it from freezing is commanding more attention now than ever before. This is a logical result of the increasing emphasis on year-round construction, but the insulation idea is also commanding increased attention among concrete men due to the development of products especially adapted to their needs.

Ordinary batt insulation has been used to a considerable extent as a means of protecting concrete from freezing temperatures. Its most serious limitation has been the inability of the liners that enclose the insulating material to stand up under the rough handling and exposure to which they are subjected on construction projects. The economic factor has also entered the picture, since the unit cost of blanket insulation is considerable unless the same material can be reused several times.

Both of these objections have been overcome by the development of special blanket insulation products specifically designed for the job of protecting exposed concrete. They differ from ordinary insulation products mainly in the strength and composition of the liners. The insulation material itself may be balsam wool, glassfiber, rock wool, or any of the substances ordinarily used for this purpose. Rigid types of insulation have also been used.

Liners perhaps most frequently consist of asphalt-saturated and coated heavy kraft paper, although at least one manufacturer has introduced a form work insulation material which consists of fibreglass encased in polyethylene film. The resilient characteristic of the fibreglass is said to enable it to return instantly to its original form after it is folded or compressed, and the polyethylene provides an excellent moisture barrier that will remain flexible even at temperatures down to 70 degrees below zero. Both the fibreglass and the film are believed to have an indefinite life, and the combined weight of the two materials is only a little over 8 pounds per 100 square feet.

Flanges are usually provided to facilitate fastening the blankets to the forms, and several widths are available to accommodate various spacings of form studding. The blankets generally come in continuous rolls and can be cut to the desired lengths with an ordinary carpenter's saw.

The economy of using insulation to protect winter concrete results from the fact that it helps retain not only the heat of the material at the time it is placed, but also the considerable amount of heat that is released as the cement hydrates. Almost all winter

concreting specifications recognize the critical importance of maintaining some minimum temperature for the 72-hour period immediately after placing. Since it is during this period that most of the heat of hydration is released, proper form insulation is often the only protection that need be provided.

Winter concrete protected with insulation also has a potential quality advantage over concrete which is protected with dry heat. When cold air is heated its capacity for retaining moisture increases markedly. For example, at 30 degrees F. a cubic foot of air will hold only 2 grains of water, but at 70 degrees it will hold 8 grains, and it will pick up this amount of water from the concrete, if conditions permit. The danger of dry hot air in summer concreting is widely recognized, but there has been some tendency to overlook the fact that the same condition can be created artificially by the protective measures adopted during winter operations.

Insulating blankets can, of course, be laid directly over unformed horizontal concrete surfaces, or applied to the outside of either job-built or prefabricated forms. The increasing use of prefabricated form panels provides an additional element of economy to the extent that the blankets can be left attached to the forms throughout the winter construction season. In the case of metal-frame form panels the insulation is attached directly to the plywood facing. The use of prefabricated forms, with insulation applied at the first onset of cold weather, has the obvious advantage of providing built-in protection for sudden temperature drops.

When all-out winter weather must be dealt with, prudence dictates that auxiliary heat be available in case insulation alone will not provide the desired protection. This is particularly important in the case of thin sections of concrete (perhaps 12 inches or less in thickness), such as slabs or walls. Here the amount of heat which can be conserved is relatively small, and the surface to be protected is large in proportion to the mass of the concrete. In such massive structures as piers and heavy foundations the total heat of hydration may be sufficient to maintain safe temperatures for many days, even when outside temperatures are far below freezing. There is always some possibility of local frost damage,

INSULATION EQUIVALENTS

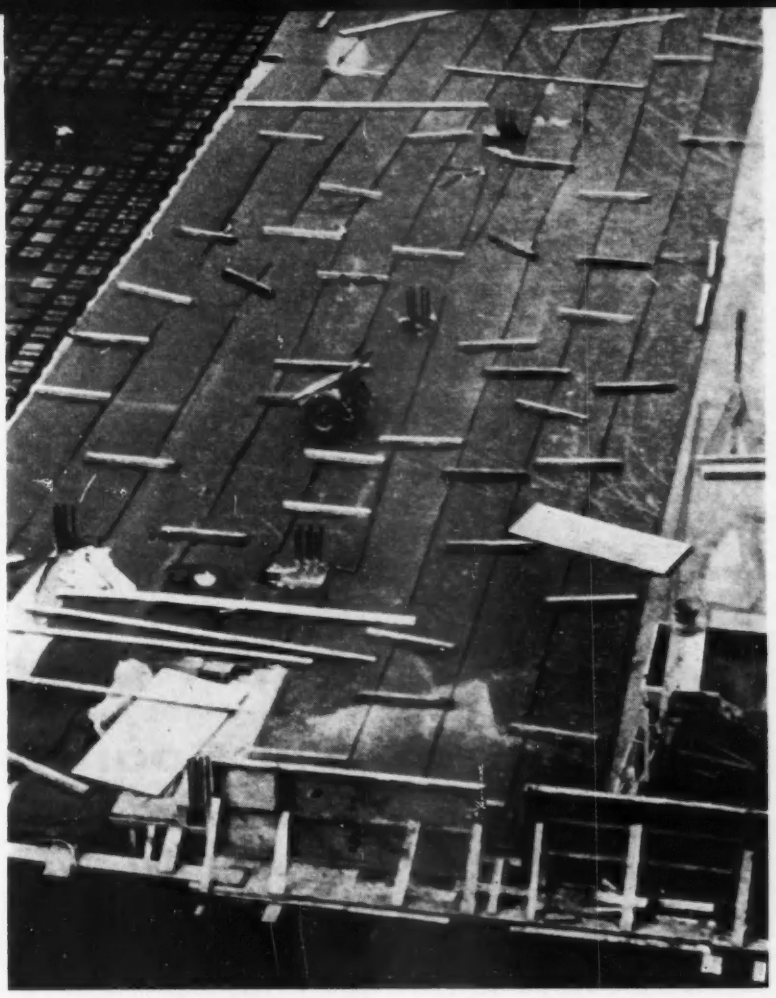
1 inch of insulating material	Equivalent thickness, inches
Commercial blanket or batt insulation	1.000
Loose fill insulation of fibrous type	1.000
Insulating board	0.758
Sawdust	0.610
Lumber (nominal)	0.333
Dead-air space (vertical)	0.234
Damp sand	0.023

This table shows the insulation equivalents of some of the materials that are used for winter protection of concrete. It indicates that it would take about 4 feet of sand to provide the same protection as 1 inch of commercial insulation.

INSULATION REQUIREMENTS FOR CONCRETE WALLS AND FLOOR SLABS ABOVE GROUND

Concrete placed at 50 F

Wall thickness, feet	Minimum air temperature allowable for these thicknesses of commercial blanket or batt insulation, degrees F.			
	0.5 inches	1.0 inches	1.5 inches	2.0 inches
Cement content—300 pounds per cubic yard				
0.5	47	41	33	28
1.0	41	29	17	5
1.5	35	19	0	—17
2.0	34	14	— 9	—29
3.0	31	8	—15	—35
4.0	30	6	—18	—39
5.0	30	5	—21	—43
Cement content—400 pounds per cubic yard				
0.5	46	38	28	21
1.0	38	22	6	—11
1.5	31	8	—16	—39
2.0	28	2	—26	—53
3.0	25	— 6	—36	
4.0	23	— 8	—41	
5.0	23	—10	—45	
Cement content—500 pounds per cubic yard				
0.5	45	35	22	14
1.0	35	15	— 5	—26
1.5	27	— 3	—33	—65
2.0	23	—10	—50	
3.0	18	—20		
4.0	17	—23		
5.0	16	—25		
Cement content—600 pounds per cubic yard				
0.5	44	32	16	6
1.0	32	8	—16	—41
1.5	21	—14	—50	—89
2.0	18	—22		
3.0	12	—34		
4.0	11	—38		
5.0	10	—40		



Bird's-eye view of blanket insulation used to protect fresh concrete in construction of parking garage.

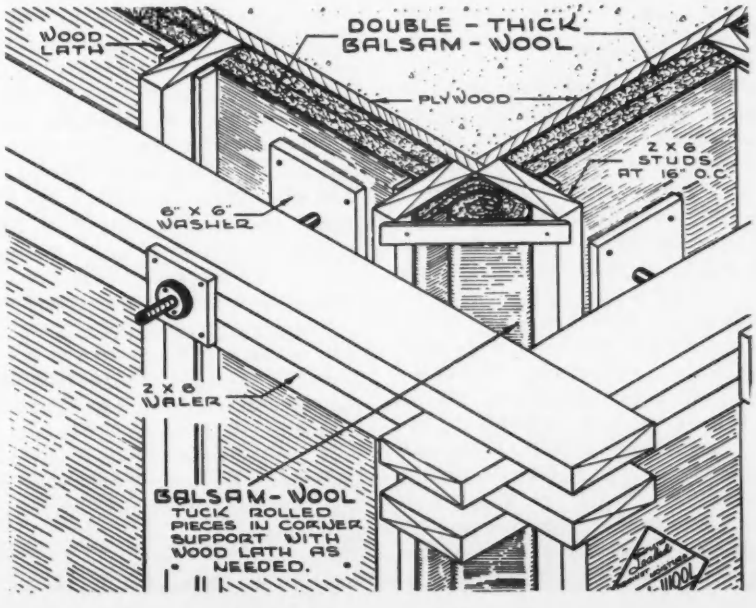
even in massive concrete, and the objective should always be to provide a comfortable margin of safety.

The American Concrete Institute's Proposed Recommended Practice for Winter Concreting, published in December, 1955, contains some very specific data on the insulation requirements of various types of concrete work under varying conditions. The accompanying table, for example, gives the minimum allowable air temperatures for various thicknesses of insulation used to protect concrete walls and above-ground floor slabs of stated thicknesses and cement contents.

What about the cost of protecting concrete with insulation as compared with other methods? Some contractors report that insulating either flat work or forms costs only half as much as providing equivalent protection with heated enclosures and watchmen for fire protection On the piers for a new highway bridge across the Missouri River at Chamberlain, South Dakota, concrete work was protected with insulation against temperatures as low as 15 degrees below zero at a cost of less than $3 per cubic yard. The contractor estimated that equivalent protection with heated enclosures would have cost at least $6 per cubic yard. On this project form panels were reused three or more times without replacing the insulation.

More and more concrete men hold to the opinion that in cold weather it is best not to strip forms from concrete until after the minimum protection period. Even without insulation, wood forms, especially if they are dry, provide considerable protection, and they serve also to distribute warmth more evenly when heated enclosures are employed. In line with this view, it seems to make very good sense indeed to go a step further and gain the advantage of low-cost protection built right into the form work.

If this opinion continues to gain ground, as now seems likely, you'll be hearing a great deal more about insulated forms. END


WOOD LATH
DOUBLE - THICK BALSAM - WOOL
PLYWOOD
2 X 6 STUDS AT 16" O.C.
6" X 6" WASHER
2 X 6 WALER
BALSAM - WOOL
TUCK ROLLED PIECES IN CORNER. SUPPORT WITH WOOD LATH AS NEEDED.

The detail drawing of a typical form shows the type of construction and the method of applying the insulation in the Chamberlain highway bridge project.

Winter Concreting Will Soon Be Routine

As simple an expedient as the use of calcium chloride offsets effect of low temperatures.

BY H. F. CLEMMER

Engineer of Material and Standards District of Columbia Highway Dept.

FROM ALL INDICATIONS, the construction industry in the United States will face throughout the next decade the greatest challenge in history. As the enormous proportions of the job become more clearly understood, there must be a growing realization that the demands soon to be made can only be met if construction activity can somehow be maintained on a year-round basis.

Concrete work probably poses some of the most difficult problems. Economic considerations have fortunately made it necessary that more and more important construction work be carried on throughout the winter months, and in consequence concrete men have acquired some hard-won experience that can now be put to good use. While there is undoubtedly much still to be learned about concreting in winter weather, we are not by any means without knowledge of the subject.

Concreting requires special attention whenever air temperature falls below 50 degrees F. at the time of placing. As simple an expedient as the use of calcium chloride will accelerate the hydration of cement so that other forms of protection will not be required until temperatures are close to freezing.

At or near freezing, materials should be heated so that the temperature of the concrete will be at least 70 degrees F. when placed. Provision should also be made for the protection of the concrete to be sure a temperature of at least 50 degrees F. is maintained for three days.

The American Concrete Institute's committee on "Winter Concreting" made a thorough study of research bearing on this problem. A report by the committee, approved by the Institute last year, includes the statement that the minimum temperature of fresh concrete after placing and for the first 72 hours should be 50 degrees F. for thin sections, and that the minimum temperature of fresh concrete as mixed for below zero temperatures should be 70 degrees F. An accompanying table presents detailed information on the control of the temperatures of the ingredients of the concrete to insure proper temperature of the fresh concrete under varying conditions. The data presented in this table is an excellent guide for the field man.

In a report presented in the *Journal of the American Concrete Institute* for June 1956, the committee stated the following minimum requirements for winter concreting:

▶ Concrete should contain entrained air and 1 percent calcium chloride by weight of cement;

▶ There should be no frozen lumps of material in the concrete as placed, or where it is placed;

▶ Concrete should be prevented from freezing and drying for at least three days after placing.

It must be understood that these are minimum requirements. If possible, a greater margin for safety should be provided. The use of calcium chloride, as recommended by the committee, assists in maintaining the proper temperature for the hydration of cement. Calcium chloride in concrete increases the rate of early heat development and accelerates the setting of the cement. The use of calcium chloride reduces by approximately one half the time required for concrete to reach maximum temperature thus off-setting the rapid loss of heat that occurs in winter operations. The increased rate of temperature development is due to the acceleration of the rate of hydration of the cement, and is one of the most important results of using calcium chloride.

Calcium chloride does lower the freezing point of the water solution, but not sufficiently to be of much practical value. The most satisfactory method of controlling the temperature of concrete is to control the temperature of the water. This is not only the easiest approach, but also the one that produces the maximum results. Since there must be no frozen lumps in the aggregates, they should be heated if necessary.

By increasing the rate of early strength development of concrete, the use of calcium chloride has some other beneficial effects that are of interest to concrete construction men. It permits earlier removal of forms, reduces the curing period in certain types of work, and advances the time when a structure can be placed in service.

The importance of taking special precautions in winter concreting operations is clearly indicated by the frequency with which modern specifications deal with the problem. Here, for example, is what the specifications of the District of Columbia have to say on the subject:

"In lieu of whatever method of curing is being used, calcium chloride shall be incorporated in the concrete

EFFECT OF CALCIUM CHLORIDE TO INCREASE STRENGTHS AT VARIOUS TEMPERATURES

Type 1 Portland Cement

5½ sacks cement per cu. yd. 2½ to 3½ in. slump

Age at Test	Compressive strength psi, Degrees F.			
	25	40	55	73
Without calcium chloride				
1 day	35	75	540	1310
7 days	575	1990	3480	4170
28 days	1470	4820	5810	5630
1 year	6350	7190	7540	6670
With 2% calcium chloride				
1 day	185	400	1290	2350
7 days	1795	3230	4280	4610
28 days	3800	4970	5850	5740
1 year	7350	7950	7460	7750

mix as directed by the engineer, whenever the temperature may be expected to reach 50 degrees F. or lower during the 24-hour period following the placing of the concrete. Two pounds of calcium chloride shall be added to the concrete mix for each bag of cement. Whenever the temperature may be expected to reach 40 degrees F. or lower during the 24-hour period following the placing of the concrete, the aggregates or water, or both, as directed by the engineer, shall be heated.

"As soon as the concrete has hardended sufficiently to prevent marring, the pavement surface shall be covered with dry burlap, building paper or similar material for protection of concrete surface, upon which shall be spread at least six inches of dry hay, straw, or other suitable material. Proper provision shall be made to hold the material in place for at least three days, or until field tests indicate that the concrete has attained the required strength.

"Placing of concrete may be started as early in the morning as the contractor desires, but shall be discontinued at 2:00 P.M. to permit the setting of the concrete before the temperature begins to drop."

To quote again from the ACI report on winter concreting:

"A major factor is the rate of strength gain at early ages. Experience and some laboratory tests indicate that if plain concrete has attained a compressive strength of 500 psi, it will not be seriously damaged by one or two freezing cycles, providing curing conditions continue to be favorable." When calcium chloride is incorporated in a concrete placed at proper temperature according to the prevailing air temperature, it is sure to gain this strength even at 20 degrees F."

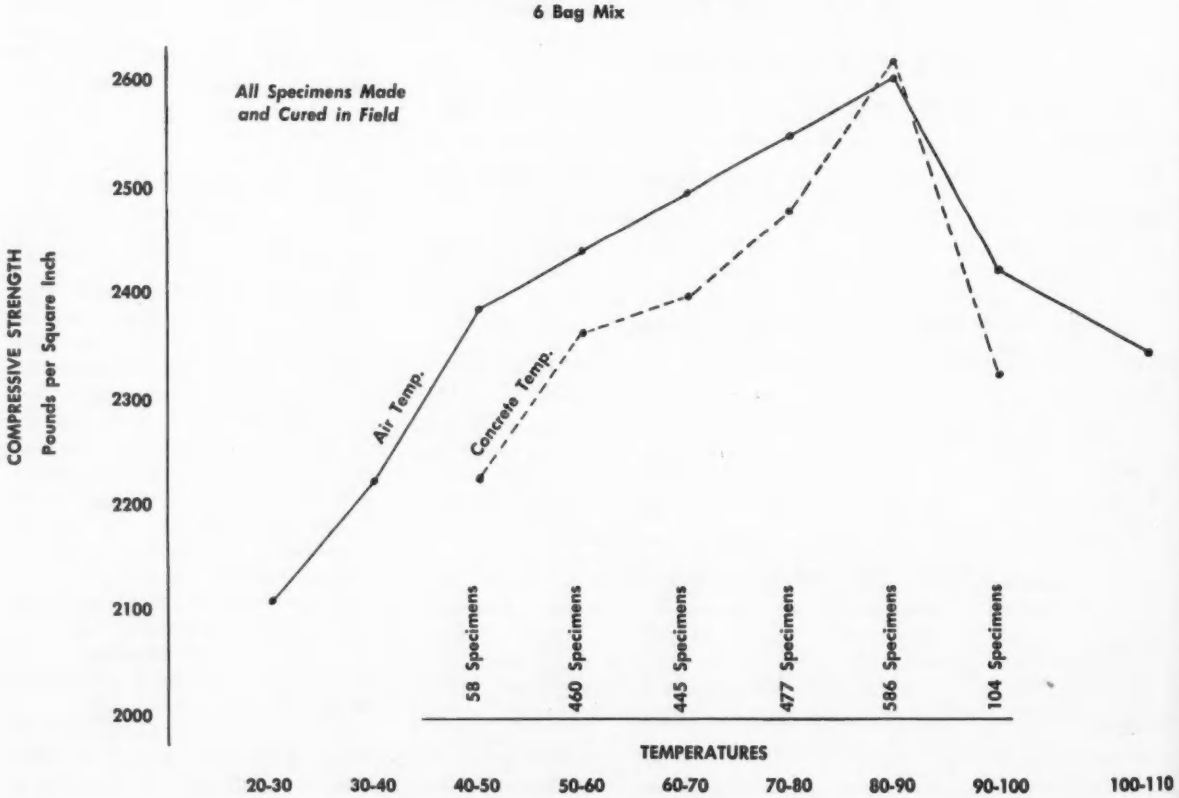
Happily many concrete men have already learned some of the techniques necessary to maintain construction schedules during severe winter weather, and there is now a wealth of evidence to indicate that none of the problems involved are unsolvable. If we are to keep to the schedule of construction necessary for the completion of the enormous building program ahead of us, we must all become specialists in winter concreting. END

If you have any doubt that temperature affects the strength of concrete, take a moment to study this graph. The data indicate strengths as affected by varying temperatures of the air and of the concrete itself.

Relative Compressive Strength of Concrete Cylinder Specimens

2130 Specimens 7-Day Strength

6 Bag Mix



Over-Turned Ready-Mix Truck Takes 4 Lives at Miami Beach

FOUR CONSTRUCTION WORKERS were crushed to death on December 13 when a loaded 7½-cubic-yard ready-mixed-concrete truck toppled into a sewer excavation at Miami Beach, Florida. Three of the men died instantly, but a fourth remained alive for over three hours while rescue workers waged an unsuccessful battle to save him.

The accident occurred behind the Miami Beach Auditorium, where the city is laying new storm sewer lines from the Dade Canal. According to eye witnesses, the loaded truck mixer was backing into position to discharge into forms when it rolled over into the excavation. The four men who lost their lives were at work inside the forms — presumably distributing concrete from a previous load.

Testimony by the foreman in charge of the job seems to contradict to some extent newspaper reports indicating that a cave-in of the embankment caused the tragedy. According to his account, the nearest wheel of the truck was 7 feet from the edge of the trench when the vehicle rolled over on its side and dropped, bottom side up, into the excavation. The driver was able to escape unharmed from the truck cab, but the four workmen, who were standing in plastic concrete, were unable to get out of the way.

About 2,000 feet of the sewer had already been poured, and there had been no difficulty with cave-ins. A 15-ton crane and other heavy construction equipment had been operated almost continuously right on the edge of the trench, and many ready-mix trucks had been driven the length of the cut without mishap.

According to newspaper accounts, the loaded truck that fell into the pit weighed approximately 32 tons. By the time four cranes succeeded in picking it up, almost five hours after the accident took place, the concrete had attained its initial set, and it was necessary to use jackhammers to recover the bodies of the victims. END

You can investigate strength of concrete in structures

at low cost and without damage by means of the . . .

CONCRETE TEST HAMMER

TECHNIQUES OF NON-DESTRUCTIVE testing of concrete have always interested materials engineers. Evaluation of the strength of concrete used in any project is usually dependent upon a compression test to failure of a typical concrete specimen. The making, curing and testing of concrete test specimens is usually required in job specifications.

Strength of concrete in existing structures can also be determined using non-destructive means—by the impact type test hammer. With this method, a quick check can be made to determine if concrete specifications have been adhered to.

In 1948 a Swiss engineer, Ernst Schmidt, conceived the idea of making a special hammer to perform concrete tests. This concrete test hammer, which is now available in the United States, makes use of the impact principle. The rebound of the impacting body is a function of the elasticity of the two bodies involved and of the initial momentum. The impact reading has been correlated to the compressive strength of concrete.

In the hammer pictured here, a single large spring provides the propelling force for striking the concrete being tested. The hammer is cocked and tripped automatically by pressing it against the surface to be tested. It can be operated with one hand if necessary.

Rebound numbers read on the test hammer can be readily converted into compressive strengths. Readings may be used without correction when the device is used in the horizontal position against vertical concrete surfaces, but small correction factors must be applied when horizontal or inclined surfaces are being tested.

For best results, readings should be taken against surfaces created by casting against a form. In any case rough spots, honeycombs, or porous areas should be avoided, as should smooth trowelled surfaces that might give excessively high readings. Rough floated surfaces should be made smooth with a carborundum stone. Sections less than 4 inches thick should be backed up by a heavy mass.

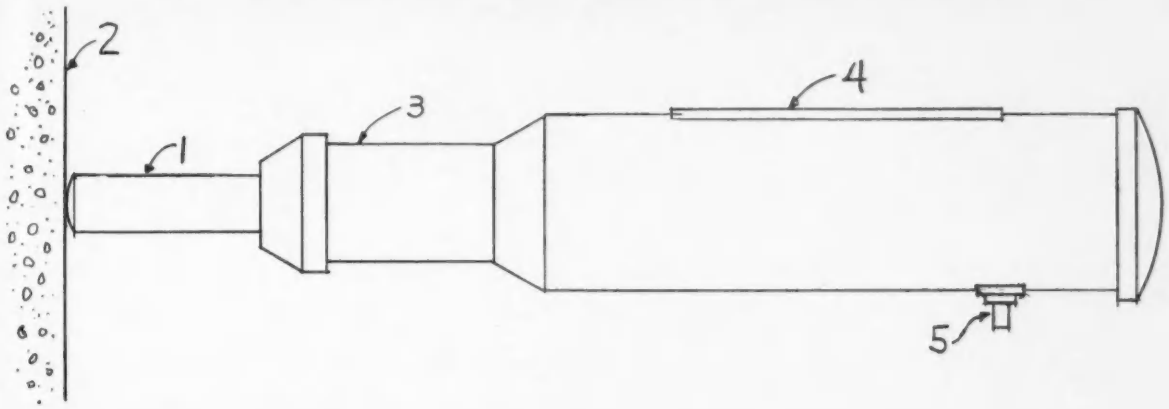
In practice about 15 readings are taken on the concrete to be tested in order to obtain a good average value of the rebound number. The best 10 readings are generally used to determine the rebound number, and the resulting average value is used to read compressive strength directly in pounds per square inch from calibration curves which are supplied with the instrument.

Because of its simplicity, the concrete test hammer can be used to determine the quality of the concrete at all accessible locations in a structure. Since the concrete is not destroyed by the test, daily tests can be made and the rate of strength gained during the curing period can be determined.

While the test hammer does not provide the consistent results obtainable from carefully-performed cylinder tests, it gives excellent results as a trouble shooting instrument, and also as a means of checking strength growth in concrete before removing forms or shoring. It appears to be one of the best methods yet devised for investigating the strength of concrete in a structure at low cost and without damage to the structure.

Readers who would like to have additional information and prices are asked to fill out and mail the reader service card facing page 24. No postage is necessary. END

Operating Instructions for Concrete Test Hammer Model II



A. After removing the instrument from the case, a light pressure on the plunger (1) will release it from the locked position and allow it to extend to the ready-for-test position. In this position the indicator should point to about 8 on the scale.

B. Press the plunger (1) against the surface of the concrete (2), keeping the instrument perpendicular to the test surface. Apply a *gradual* increase in pressure until the hammer impacts. Hold the instrument firmly against the concrete and read the scale (4). *Do not touch the button (5) while depressing plunger.*

C. If not convenient to read the scale (4) while maintaining the instrument against the concrete, press the button (5) *after* impact, and remove the instrument from the test position for reading.

D. Light pressure against the plunger (1) will release it from the locked position, and when fully extended, the instrument is automatically reset for another test.

Photo by courtesy of Soiltest, Inc.

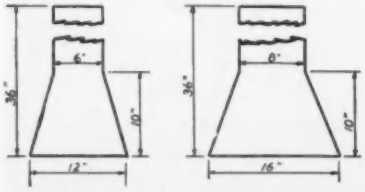
Photo by courtesy of Barber-Greene

As a follow-up to last month's article about slab-floor house footings which were dug in an average of 30 minutes each, here is the story of an interesting ditcher accessory which makes it possible to pour flared footings at very little more than the cost of ordinary straight footings

Special Cutter Beats Down Cost of Flared Footings

AN ILLINOIS home-building contractor has reported savings of from $400 to $500 each on a total of more than 800 slab-floor dwellings! This saving was achieved in the cutting of trenches for foundation footings, and is attributable to lower forming costs resulting from the use of a small vertical-boom service ditcher equipped with an interesting flaring device.

In the particular F.H.A. area in which the contractor operates, slab-floor dwellings are constructed over more-or-less conventional concrete footings, except that the footings must be flared out to a base twice as thick as the wall of the footing itself.



These are the footing cross-sections which were dug with the flared cutter.

To do this by hand would have meant digging trenches twice as wide as necessary. It would also have been necessary to provide and install special forms, and after pouring and stripping there would have been considerable extra excavation to backfill.

As a means of avoiding all this trouble and expense it was decided to employ a service ditcher equipped with an unusual rotating flared cutter operated from a power takeoff on the machine's regular vertical digging boom. As the accompanying illustration shows, a rotating vertical shaft was added immediately behind the regular digging line. At the foot of this shaft is a stirrup-like, trapezoid-shaped cutter, rotated by the shaft through a power takeoff from the digging boom headshaft.

To begin a trench, the regular digging boom was set into operation. The flared cutter was set so that its base was on the center line of the trench. When the digging boom reached the desired depth (in this case, 36 inches) the cutter began to revolve, widening the bottom of the trench to the desired width. Following directional guide lines, one side of the foundation footings was dug; the boom was raised, the ditcher turned at right angles and the second side begun. This procedure continued until all four sides had been completed.

On this contract, it was found possible to pour all footings and the slab floor in a single operation. To do this, 8-inch forms were set in place all around the outside of the footing excavations. Four-inch forms were set on the inside and the interior area received a 4-inch pad of gravel. After this was in place, the footings and the 4-inch concrete slab were poured simultaneously.

Operating speed was helped along on this project by leveling the ground with a grader before the footing excavation began. This not only gave the ditching machine a level surface to work on, but it also facilitated pouring the floor slab. **END**